EXHIBIT L

GTN MARKET FORECAST

GENETICALLY ENGINEERED CORN: BREAKTHROUGH BRINGS MARKET CLOSER

Effective techniques have now been developed that bring commercial genetically engineered corn much closer to reality. Corn is the largest US agricultural crop in terms of both value and acreage. As such it has figured prominently in *GTN*'s earlier forecasts of markets for plants into which new traits have been introduced through genetic engineering. These forecasts were based on the assumption that techniques would be developed that would make it feasible to genetically engineer corn, just as was already possible with many dicot broadleaf plants. However, the Ti plasmid, which is very effective in introducing new genes into broadleaf plants, does not work with corn and other monocot plants, such as wheat, other small grains, and grasses. Reports that other methods, such as using gene guns to blast small metallic particles covered with DNA into cells, have been used to introduce foreign genes into corn have appeared recently. Most of these reports are of only partial successes. Often transformed cells can't be regenerated into complete plants, or if they can be, the plants are sterile. Now a peer-reviewed paper has appeared describing research at DeKalb Plant Genetics that succeeded in transforming corn cells with a foreign gene and regenerating them into complete plants that pass the new genes on to succeeding generations through their seed (*Plant Cell* 2, 603). Now we know for sure that it is possible to genetically engineer corn.

US MARKET FOR GENETICALLY ENGINEERED CORN SEED

Improvement	Market ($ million/yr)
Resistance:	
Herbicide	150
Insect	70
Nematode	133
Other improvements	
Corn oil	7
Male sterility	75
Protein	50
Total	485

Source: Genetic Technology News©

Market Value Will Come from Premium Prices: We assume that suppliers of genetically engineered seed corn will be able to charge a price carrying a premium over the price for ordinary seed. Added revenues from sales of improved seed are listed as market values in the table above. Improvements, such as insecticide or herbicide resistance or male sterility, that can be made by introduction of a single gene could be commercialized as early as 1995. It will take longer for improvements requiring more complex genetic changes or genes which have not yet been identified. There should be no reason why most or all of these improvements cannot be incorporated into a single corn variety.

Herbicide-resistant corn will save farmers about $70 million/yr in herbicide costs -- by making it possible to use cheaper or more effective chemicals -- and by reducing the number of applications needed each season. Herbicide-resistant varieties will save an estimated additional $230 million/yr by controlling weeds not controlled by current herbicidal practices. We estimate that half of the value of this $300 million total savings will accrue to the seed supplier.

Insect-resistant broadleaf plants are already being field tested. It should not require very much time to introduce the same insecticidal protein genes used in these plants into corn. However, currently known resistance genes are not active against all species of insects. We assume that genetically engineered corn will make it possible to eliminate half of the $280 million farmers now spend on insecticides for corn, and that the additional value that insect resistance would bring to corn seed will be approximately half of that.

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Nematode-resistant corn seed should command a premium of about 25% of the savings resulting from prevention of nematode losses of the corn crop. Although we usually estimate that sales of a product controlling a loss will amount to half of the savings, we believe that losses due to nematodes are not as well perceived as most losses, so farmers will be less likely to pay for protection. We estimate that nematode losses are equal to about 5% of the $21-billion corn crop. Unlike most of our other estimates, we assume only a 50% market penetration for this improvement.

Corn oil is an important byproduct of the corn wet milling industry. Like other vegetable oils in could be improved by changing its fatty acid content. Our market estimate is based on the assumption that improved corn oil will increase the value of the current $280 million corn oil market by 10%. Seed suppliers will probably only realize about a quarter of this increased value, which must be shared not only with farmers but with corn processors and oil marketers.

Male sterility prevents self pollination in plants. Introduction of this trait into corn would save seed producers the $75 million/year they now pay for detasseling -- removal of male flowers from corn plants by hand -- so that pollen from a different corn variety can be used to produce hybrid seed. Seed producers should be able to retain all of these savings.

Protein quality of corn could be improved by modifying proteins found in the grain so that they have better balanced levels of essential amino acids. This would lower the quantity of supplements needed with corn to provide a complete feed. We estimate that US seed corn producers could receive additional revenue of $50 million/yr for varieties with a good amino acid balance.

LEADING COMPANIES INVOLVED IN GENETICALLY ENGINEERED CORN

Company	Comments
Agracetus Middleton, WI	Has used a gene gun to transform corn and other plants. The company is a wholly-owned subsidiary of W. R. Grace (New York, NY).
BioTechnica Cambridge, MA	BioTechnica has succeeded in transforming corn, but has not revealed how it has done so. Corn research goals include oil improvement and insect resistance.
DeKalb Genetics Dekalb, IL	Used a gene gun to insert a herbicide-resistance marker gene into corn cells and regenerated them into fertile plants whose seed pass the gene on to succeeding generations. This is the first successful research that has appeared in a peer-reviewed journal.
Monsanto St. Louis, MO	Has regenerated transformed corn cells into complete plants, which were fertilized with pollen from other plants to produce a new generation of seedlings. Half the seedlings carried the foreign genes. Transformation was done by US Department of Agriculture researchers. They used a gene gun to introduce two marker genes into corn cells.
Pioneer Hi-Bred Des Moines, IA	Just signed an agreement with Plant Cell Research Institute (Dublin, CA), part of Montedison (Milan, Italy), to develop corn with improved amino acid balance. Works with Ecogen (Langhorne, PA) and Agricultural Genetics (Cambridge, UK) to obtain insect-resistance genes.
Plant Genetic Systems Gent, Belgium	PGS has a proprietary technique for transforming plants with a gene for male sterility.
Sandoz Basel, Switzerland/East Hanover, NJ	Used an electroporation process to insert a marker gene into corn cells, which were regenerated into complete plants.

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Biotechnology in Germany: *GTN* covered Biotechnica '90, The International Trade Fair and Congress at Hannover, Germany, last month. Here is a sampling of a few of the many things going on in German biotechnology.

Recombinant DNA Technology Improves Amino Acid Processes: A Japanese discovery 30 years ag that a strain of *Corynebacterium glutamicum* deprived of the vitamin biotin excretes glutamic acid lead to development of processes than now produce over 500,000 metric tons/yr of the product worldwide. Researchers at Germany's Research Center Jülich are using the same bacterium to produce other amino acids, L-lysine and L-threonine, the center's Hermann Sahm told the Congress. Degussa (Frankfurt/ Main, Germany), a major producer of amino acids, sponsors the work.

The bacterium starts with glucose and ammonia and produces L-lysine by a process with several intermediate steps, each catalyzed by a particular enzyme. The German researchers have used recombinant DNA technology to improve or change the process in three different ways. The simplest was to determine the rate-limiting steps and improved them. They did this by cloning the genes coding for each of the enzymes of the biosynthetic process. They then constructed a series of *C. corynebacterium* strains, each one transformed with plasmids to increase the copy number of the gene coding for the particular enzyme that catalyzed one of the steps in the process. By studying the yields of each of the transformed strains they determined that two of the steps were bottlenecks, whose yields were improved by the presence of the extra genes coding for the appropriate enzymes.

A second approach was to control the flow of intermediates at a branching point. One of the intermediates in the process, L-aspartate semialdehyde, can be converted either into the next intermediate for L-lysine synthesis or to a different intermediate, which leads to synthesis of a different amino acid, L-threonine. By adding plasmids to bring about overexpression of the gene for the enzyme in the L-lysine pathway yields were increased. It was also possible to overexpress the other enzyme, and end up with a process that produced L-threonine, with very little L-lysine.

A third method of modifying amino acid synthesis was to modify the synthetic pathway by introducing genes from *Escherichia coli* for enzymes that could convert a different starting material into one of the intermediates further down the line. This opens up possibilities for not only improving amino acid syntheses, but for entirely new bacterial syntheses for a variety of chemicals.

Details: Dr. Hermann Sahm, Director of the Institute for Biotechnology, Forschungszentrum Jülich, Postfach 1913, D-5170 Jülich. Phone: (02461) 613294. Fax: (02461) 613870.

FZB Biotechnik Looks West for New Partners: An East German biotechnology organization, FZB Biotechnik, stands to lose everything unless it can find new sources of R&D support soon. With German reunification, FZB lost is chief client, another East German government organization. FZB has changed itself from a government organization into a corporation and is looking for private industrial partners from West Germany, the United States, and elsewhere. It has cut its staff from 480 to 280. By the end of the year staff will be cut further, to 200. The new company offers licenses for processes, contract R&D capabilities, analytical services, and a few biotechnology products for sale.

Most of FZB's earlier work was done in traditional fermentation processes. It has developed industrial fermentation processes for making citric acid and L-lysine. The organization maintains a pilot plant for fermentation and downstream processing.

In 1986 FZB shifted its emphasis towards molecular biology. It now has mammalian cell lines for production of human growth hormone, tissue plasminogen activator (t-PA), and monoclonal antibodies. Its product line includes a number of different bacterial proteases, cellulases, and other enzymes with research and industrial potential. The company also has the capability for enzymatic production of optically active, chiral compounds. Collagen for support of cultured cells, oligotides, bacterial rhodopsin pigment, and microbial pesticides, are also available.

Details: Dr. Martin Ulitzsch, Scientific Communication and Marketing, FZB Biotechnik GmbH, lin, Alt-Stralau 62, O-1017 Berlin, Germany. Phone: (00372) 5501-0. Telex: 112 784.

al Finally Gets OK to Start Building Recombinant Prourokinase in Germany: The new technology law should make it easier to manufacture recombinant proteins there. However, Leopold Flohé told the Congress it is still not clear how well the law will work. Grünen- ently finally obtained permission to begin construction of its plant to produce recombi- okinase (PUK) in Germany. The company submitted its application in 1988.